

## **ATTACHMENT 6**

### **VOICE/DATA MOBILE RADIO SYSTEM**

**FOR**

### **PROCUREMENT OF 40 FT LOW-FLOOR BATTERY ELECTRIC BUSES**

**SPECIFICATION NO. VE21-054**



Massachusetts Bay Transportation Authority  
Vehicle Engineering  
Boston, Massachusetts

## PART 1 - GENERAL

### 1.00 DESCRIPTION

#### A. General Mobile Voice Radio Description

All mobile voice radio equipment shall be provided by the Contractor and shall be fully functional and inter-operable with all elements of the digital trunked voice, as well as all elements of the low density data (LDD) simulcast radio communication system currently in use by the MBTA. The ability to operate on any programmed combination of 20 duplex, FCC-approved radio channels (40 frequencies), at any time, over the 800 MHz NPSPAC band is required. The radio shall transmit and receive both voice and LDD communications in digital form.

#### B. Feature Levels

The mobile voice radio basic level shall provide features related to a digital trunked radio system. Such as call alert decode and the capability to participate in private conversation. The mobile radio will remain at all times under dispatcher control.

The mobile voice radio equipment shall also be provided with the following general features:

1. Capable of dual mode operation in both trunked and conventional systems. Conventional mode of operation shall utilize continuous tone coded squelch system or digitally coded squelch.
2. Automatic identification of all transmissions (vehicle ID number) from all mobile voice radios. All Radio ID numbers must be capable of ready translation into User ID aliases both at the radio unit and from a control center workstation.
3. Selective addressing of a particular bus, all buses in a group, all buses in an MBTA transit service area, or all MBTA buses, as desired by the MBTA, at any time.
4. Trunked control of channel switching of vehicle transceivers.
5. Connections and circuitry for the encoding and transmission of mechanical alarms (including an emergency alarm) from contact closures external to the radio.
6. Limited remote controlled testing of vehicle mobile voice radio functions as well as driver startup controlled testing of functions such as emergency alarm. Emergency test alarm will be auto-acknowledged.
7. Data ready through a standard RS-232, RS-422, or the standard interface.
8. Other functions as necessary to meet the equipment and system performance requirements described in this document.

#### C. Mobile Voice Radio Purpose

The mobile voice radio transceivers, which the Contractor shall provide for each bus, will be used throughout the MBTA service area by Operators to communicate with Dispatchers, at the Operational and Backup Control Centers, and with various platform and street supervisors.

## D. Quantities of Equipment

The Contractor shall submit and provide the specified quantities, pending Authority approval, the specified mobile voice radio transceiver equipment for each bus, complete with telephone style handset, rooftop antenna, DC/DC converter, and loudspeakers. The Contractor shall also provide the required number of sets of complete programming equipment, software, programming instructions, and equipment operations and maintenance manuals

## 1.01 MAJOR ELEMENTS

The Contractor shall furnish and provide to the MBTA, digital voice/LDD mobile radio equipment consisting of the following major elements:

### 1. Mobile Voice Radio Transmitter/Receivers (Transceivers)

Provide trunked, digital, voice/LDD mobile radio transceivers, as specified in this Chapter. The radio transceivers shall operate within the MBTA licensed 800 MHz NPSPAC frequency band. The transceivers shall not exceed 2.5 inches x 8 inches x 10 inches (H x W x D).

### 2. 800 MHz Antenna Systems

All vehicles to be equipped with mobile voice radio transceiver equipment shall be provided with mobile radio, omni-directional antenna systems, as described herein. The antenna systems shall consist of durable and corrosion resistant, unloaded type antennas for use in the 800 MHz NPSPAC frequency band.

### 3. Enclosures and Mounting Hardware

Provide all required equipment enclosures, lockable mounting brackets, mounting frames, cables, connectors, and installation hardware and accessories.

### 4. Power Conversion/Conditioning

As deemed necessary for proper EMI free operation, mobile voice radio equipment shall be provided with the power conversion and conditioning equipment as specified.

### 5. Ancillary Equipment

Provide all ancillary equipment, materials, and services necessary for the subject voice mobile radio system to meet the specified reliability requirements described in these Specifications.

## 1.02 MOBILE VOICE RADIO TRANSCEIVER PERFORMANCE REQUIREMENTS

### A. Design Requirements

The Contractor shall provide state-of-the-art, mobile, digital, trunked voice, radio transceiver equipment, which operates on the licensed 800 MHz NPSPAC frequency band in an efficient manner. The radio transceiver will be equipped with the IMBE vocoder protocol, shall provide high quality voice and LDD communications performance, shall exhibit low maintenance, high reliability, and user

friendly operation, and have a flexible, software-based hardware configuration to accommodate future system needs.

## B. Performance Requirements

The Contractor shall provide a mobile voice radio transceiver that is fully functional and interoperable with the currently active MBTA Radio System.

## **1.03 QUALITY ASSURANCE**

1. Establish and maintain written procedures defining the Quality Assurance system. Procedures shall encompass all phases of the system to include, but not be limited to, within the Contractor's organization:
  - Receiving Inspection
  - Production and Process Control
  - Functional Testing
  - Discrepancy Control
  - Measuring and Test Equipment Calibration/Certification
  - Drawing Control
  - Quality Assurance Records
  - Shipping Inspection
  - Other Quality Specification to Meet the Requirements of the Contract

Materials and equipment shall be new and furnished by same supplier. The use of refurbished or remanufactured materials shall not be permitted.

## **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. The Contractor shall deliver, store, and handle all materials and equipment in such a manner as not to degrade quality, serviceability, or appearance.
- B. The Contractor is responsible for complete installation and testing verification of all equipment prior to acceptance of each bus for revenue service.
- C. Materials and equipment, as received by the MBTA, and are determined by the MBTA, to be damaged, shall be replaced at no additional cost to the MBTA. The Contractor shall also be responsible for replacing lost or stolen materials and equipment at all times prior to acceptance at the MBTA storage location.

## **1.05 ELECTRICAL POWER REQUIREMENTS**

DC to DC converters as required. Components shall be certified to operate normally, within pre-established output levels, while the input voltage varies as much as plus/minus 10 percent.

## **1.06 ENVIRONMENTAL REQUIREMENTS**

Vehicle mobile voice radio components are designated as On-Vehicle equipment.

### A. Temperature

1. On-Vehicle Equipment

The On-vehicle equipment shall be designed, fabricated, and environmentally tested to operate in the temperature range from minus 25 degrees to plus 60 degrees Celsius (C) with a relative humidity range of 5 percent to 95 percent, non-condensing.

## B. Weather and Elements

1. All directly exposed On-vehicle equipment, and any other potentially exposed units, shall be designed and tested to operate continuously and reliably in varying conditions of humidity, rain, salt, dust (including steel dust), cleaning detergents, water spray, roadway chemicals, exhaust emissions, and other contaminants found in the transportation areas. This means that appropriate rain/corrosion/tightness testing shall be conducted for all vehicular equipment.
2. All Exterior, Interior, and On-vehicle system components shall be designed and finished to resist adverse effects from solar radiation.
3. Certification by a qualified testing laboratory stating that the equipment has been previously tested and is capable of meeting or exceeding the above requirements will be acceptable in lieu of testing the equipment proposed for vehicular use.

## 1.07 WARRANTY

1. The Contractor shall obtain the standard, written manufacturer's warranty, in the MBTA's name, for all equipment furnished but manufactured by others.
2. During the warranty period, if spare components are not available, the Contractor shall be responsible to provide warranty repairs directly or through their authorized representative.

## 1.08 SUBMITTAL

The Contractor shall comply with the documentation requirements while providing the following:

1. System Software Manuals
2. Manufacturer's Systems, Operations and Maintenance Manuals.
3. Factory Integration

These activities shall include equipment manufacture factory acceptance test, and equipment delivery to sites.

4. FCC Type Acceptance
5. Environmental Requirements

## PART 2- PRODUCTS

### 2.00 GENERAL DESCRIPTION

The Contractor shall furnish all products, services, and documentation necessary to meet the requirements in this specification, including but not limited to the following:

1. Mobile Voice Radio Equipment

The mobile voice radio transceivers shall operate in the spectrum of the MBTA licensed frequencies in the 800 MHz NPSPAC band.

2. Operator Control Unit (Head)

The Operator Control Unit (OCU) shall be capable of providing audio input/output connections and signals to the handset or microphone and loudspeakers.

The Bus Operator Control Unit (OCU) includes the Vehicle Operator Control Head; a handset; a loud speaker; a silent (emergency) switch/alarm; and a Vehicle Local Area Network (SAE J1708 or J1939) interface. Other essential subsystems that have to be connected to the Control Unit, for full CAD/AVL functionality, are the Onboard Computer/Mobile Data Terminal (MDT), which runs the CAD software and the AVL subsystem, which includes the GPS receiver and antenna. In addition to these components, both mobile voice and data radios have to be provided as the wireless communications link as well as providing PA/VMS capability. The radio communications, along with the GPS receiver, shall provide real-time position data and a means to communicate location and other data.

3. Antenna Systems

The Contractor shall provide low profile, radome type antenna systems for all buses in an Authority approved location, proposed by the Contractor during the design review process. The 800 MHz NPSPAC transmitting and receiving antenna systems shall include the following:

- a. Three dB gain antennas
- b. Antenna housing
- c. Coaxial cables
- d. RF connectors
- e. Mounting hardware

4. Power System

Provide the required power conversion and conditioning equipment to handle both two way and CAD/AVL mobile radio transceiver equipment and other supplied mobile equipment on each specified vehicle, in accordance with specifications.

5. Handset, Microphone and Loudspeakers

Provide the required quantities, as identified in the Technical Specification, Section TS 79 and Attachment 4, of telephone style handsets and speakers for each bus.

## 6. Programming Equipment and Materials

Provide the specified quantities of transceiver programming equipment, i.e. software and instructional materials. Programmed equipment shall be flash programmable for future software enhancements.

## 7. Ancillary Equipment and Materials

The Contractor shall provide all equipment and materials required for MBTA to place into permanent operation the voice mobile radio units while achieving the specified reliability.

## 8. Alarm Interfaces

The Contractor shall provide in vehicle mobile voice radio equipment an emergency alarm interface that can be used to transmit various types of status alarms.

## 9. Equipment shall be completely compatible with the existing MBTA Radio System.

# **2.01 MOBILE VOICE RADIO TRANSCEIVER REQUIREMENTS**

## A. General

### 1. Mechanical Requirements

The mobile voice radio transceiver shall be designed for remote mount capability. The mobile voice radio equipment to be provided shall be specifically designed to exhibit rugged and reliable performance in demanding environments. The units shall meet the physical shock, vibration, immersion, and rain resistance requirements for On-vehicle equipment.

### 2. Environmental Requirements

The mobile voice radio transceiver shall be constructed to withstand the environmental tolerance testing required for On-vehicle equipment.

### 3. Electrical Power Requirements

The radio transceiver shall be designed to operate from electrical power sources ranging from 10.8V DC to 16.8V DC. The radio shall not exhibit any significant deterioration in performance when powered from electrical sources with sudden voltage swings of up to two volts peak-to-peak (2 Vp-p). The transceiver power input circuitry shall be provided with protective devices to avoid damage from (a) reverse polarity and (b) transient overvoltage. The electrical power input of the transceiver shall also be provided with an overcurrent protection device, such as a fuse or circuit breaker, to minimize damage to the transceiver and to the vehicular electrical system in the event of a short circuit or other anomaly in the transceiver.

## B. Transmitter

- |                               |                |
|-------------------------------|----------------|
| 1. Operating Frequency Range: | 806 to 824 MHz |
| Frequency Separation:         | -45MHz         |
| Talk Around:                  | 851 to 870 MHz |

2. Power Output Range:	20 to 40 watts
Temperature range:	Minus 30 degrees Celsius to plus 60 degrees Celsius (plus 25 degrees Celsius ref)
3. Frequency Stability:	Plus/Minus.00015 percent
Temperature range:	Minus 30 degrees Celsius to plus 60 degrees Celsius
4. Radiated and Conducted Harmonic and Spurious Emissions:	Minus 70 dBc EIA - 603 standard
5. Modulation/Deviation Limiting:	Plus/minus 5 kHz (plus/minus 4 kHz NPSPAC)
6. Output Impedance:	50 Ohms
7. FM Hum and Noise:	Minus 45 dBc or better
8. Audio Distortion:	Less than 5 percent
9. Automatic Time-Out Timer:	1- to 90-second programmable time interval Audible tone capable

#### C. Receiver

1. Operating Frequency Range:	851 to 870 MHz
Frequency Separation:	-45MHz
Channel Spacing:	25 kHz (12.5 kHz @ NPSPAC)
2. Frequency Stability:	Plus/Minus.00015 percent
3. FM Hum and Noise:	Minus 45 dBc or better
4. Input Impedance:	50 Ohms
5. Adjacent Channel Rejection (Selectivity EIA2-Signal):	Minus 80 dB or better @ 25 kHz in accordance with EIA-603 standard
6. Spurious Response Rejection:	Minus 90 dB or better
7. Digital and Analog Sensitivity (1 percent BER, EIA SINAD):	microvolts (minus 116 dBm) or better
8. Audio Power Output:	External/Internal Speakers, 5 watts (@ less than 5 percent distortion)
9. Intermodulation Rejection:	Minus 80 dB or better

#### D. FCC Type Acceptance

The mobile voice radio transceiver shall be designed, manufactured, and tested to comply with the FCC Rules and Regulations Parts 22 and 90 and be of a type listed on the latest version of the FCC "Radio

Equipment List" for use in the 800 MHz NPSPAC frequency band. The Contractor shall provide proof of FCC "Type Acceptance" for the subject radio, over the required frequency range, by including the manufacturer's "Type Acceptance Number" with the submittal described in Chapter VII, Shop Drawings, Product Data, and Samples.

#### E. National Channels

All Mobile Voice Radios shall in addition to the MBTA voice channels include the national call in channel and national mutual aid call in channel. The operation is in the analog voice conventional repeater mode. The operating frequencies are follows:

National Call in Channel

- a) 851.0125 Receive
- b) 806.0125 Transmit

National Mutual Aid Channel #2

- a) 852.0125 Receive
- b) 807.0125 Transmit

National Mutual Aid Channel #3

- c) 852.5125 Receive
- d) 807.5125 Transmit

MBTA will use infrastructure installed by the State Police. The intent is to have these available if an emergency arises.

## **2.02 VEHICLE MOBILE VOICE RADIO EQUIPMENT**

#### A. General Vehicle Mobile Voice Radio Equipment Requirements

The Mobile Voice Radio equipment to be provided for the MBTA vehicles shall be specifically designed to conform to environmental conditions as specified. The radio shall be operable in trunked mode, on any programmed combination of 20 duplex, FCC-approved radio channels, at any time, over the 800 MHz NPSPAC band. The radio shall be capable of transmitting and receiving both voice and LDD communications completely in digital form. The MBTA Radio shall be provided with connections and circuitry for the encoding and transmission of an Emergency Alarm.

#### B. Radio Equipment Configuration

The Mobile Voice Radio shall include a transceiver, remote mount operator control unit, noise canceling palm microphone (non-revenue) or heavy duty (MIL-SPEC cable and connector) telephone style handset (revenue) with a cord, cradle, and hook switch, antenna, and waterproof (5w minimum) loudspeaker. Equipment shall not be riveted and shall be removable with a fastener type system as approved by the Authority. A DC/DC converter shall also be utilized on specified vehicles. The radio transceiver shall be remotely mounted in the vehicle. A mechanically suitable mobile antenna assembly shall be mounted on the vehicle and connected to the transceiver with a Teflon-insulated coaxial cable. The operator control unit shall be a remote mount, low profile unit mounted in a vandal-resistant enclosure. New heavy duty (MIL-STD cable and connector) telephone style handsets with a cord, cradle, and hook switch shall be provided for buses and trackless trolleys. A waterproof (5w minimum) loudspeaker shall operate when the handset is "on-hook."

### C. Emergency Alarm and Covert Microphone Operation

An external emergency alarm (EA) push-button switch located on the floor, near the operator, is used for activation of a silent alarm, via radio, to the MBTA Control Center during life threatening emergency conditions. The radio must be designed to interface to this external switch and to provide unit ID and notification of the emergency to the dispatcher within 0.5 seconds of engaging the switch. With the Mobile Voice Radio system receipt of a silent acknowledgment of the alarm from a META Console Operator or Transportation Service Manager via the radio system, the following operations shall automatically occur:

1. The Operator Control Unit shall display an innocuous and obscure change in display mode which an untrained person would most likely ignore.
2. The mobile voice radio shall be automatically placed in voice-transmit mode to permit MBTA dispatchers to "eavesdrop" on events occurring on the revenue vehicles.

Covert microphone and external emergency alarm switch to be provided by others.

3. All specified CAD/AVL equipped vehicles will have emergency alarm switch provided by CAD/AVL Contractor.

### D. Power System

Electrical power conversion and conditioning equipment shall be provided as required for the Mobile Voice Radio transceiver equipment on each specified revenue vehicle. MBTA trackless trolleys to be equipped with Mobile Voice Radios shall also be equipped with 12 to 12 Volt DC to DC converters. Trains and LRVs to be equipped with Mobile Voice Radios shall be equipped with 36.5 to 12 Volt DC to DC converters. MBTA buses are to be equipped with EMI filters, which are to be provided by others.

### E. Radio Rooftop Antenna System

The mobile rooftop antenna shall be designed and manufactured to be thoroughly and mutually compatible with the Mobile Voice Radio transceiver unit. The radio antenna shall be designed for use in the 800 MHz NPSPAC frequency band.

Low profile Type:

1. Antenna - Low profile, vertically polarized, omni-directional, three dB gain, type antennas enclosed in the antenna manufacturer's weather resistant housing. The antenna shall come equipped with a waterproof mounting base to seal out moisture, and all hardware necessary and required to provide a complete and fully operational mobile antenna system.
2. Coaxial Cable and Connector Assembly - Low loss, vibration and corrosion resistant RF connectors will be soldered (or an approved crimp-on type connector) to low loss, rugged, heat resistant coaxial cable. The outer jacket insulation shall withstand service at temperatures up to 200 degrees Celsius without exhibiting any significant signs of damage. The cable center conductor shall be stranded or solid pure copper (copper clad steel will not be accepted), and the shield shall be braided copper. The dielectric insulation material shall be made of type FEP fluorocarbon foam, and the protective jacket shall be made of Teflon. The cable shall exhibit no greater than -10 decibels of attenuation per one hundred foot length, at 800 MHz NPSPAC.

## F. Additional Mobile Voice Radio Requirements

The radio equipment shall provide the following functions during two-way voice radio communications:

1. Automatic identification of vehicle ID number during all fleet radio transmissions from MBTA vehicles.
2. Database selective addressing of a particular vehicle, all vehicles on a route, all vehicles in a MBTA district (transit service area), or all subject MBTA transit system vehicles, as desired by MBTA, at any time.
3. Request-to-Talk (RTT) signaling from a vehicle.
4. Priority-Request-to-Talk (PRT) signaling from a vehicle.
5. Automated self-diagnostics of radio upon vehicle departure from yard or garage.
6. Other control functions as necessary to meet the equipment and system performance requirements described in this document.

## PART 3 - EXECUTION

### 3.00 DESCRIPTION

The Contractor shall furnish all services, equipment, and documentation necessary to place into operation the Mobile Voice Radio Equipment specified.

### 3.01 MINIMUM REQUIREMENTS

This specification contains the minimum requirements for the Mobile Voice Radio and Ancillary Equipment. The Contractor shall ensure that the Mobile Voice Radio equipment offered in response to this specification incorporate all latest service proven technological advances and shall be totally compatible with the existing MBTA radio system. The Contractor shall discuss with the Authority to confirm that the latest technological advances are incorporated in the final design of the Radio System. The Mobile Voice Radio and all Ancillary Equipment shall be submitted to the Authority for approval during the Design Review Process.